STREAM CHANNELS

Characterization

The North Fork Coquille Watershed contains approximately 1,060 miles of streams based on the GIS streams layer. Table Chan-1 shows the miles of stream by order and subwatershed. The watershed has a high drainage density, generally arranged in a dendritic pattern. The GIS data show an overall stream density is 6.9 mi./sq. mi. Table Chan-2 shows stream density by stream order and subwatershed.

As shown on Map Chan-1, the 6th order streams and the lower reaches of the 5th order streams flow predominantly through private land. These include the mainstem reaches in the North Coquille Mouth and Fairview Subwatersheds, and the lower valley bottom sections of Middle Creek and Cherry Creek. They are low gradient, entrenched, meandering reaches and generally bordered by flood plains. Most the rest of the channels flow through a steep, deeply dissected, and forested landscape.

Table Chan-1: Stream Order Miles by Subwatershed

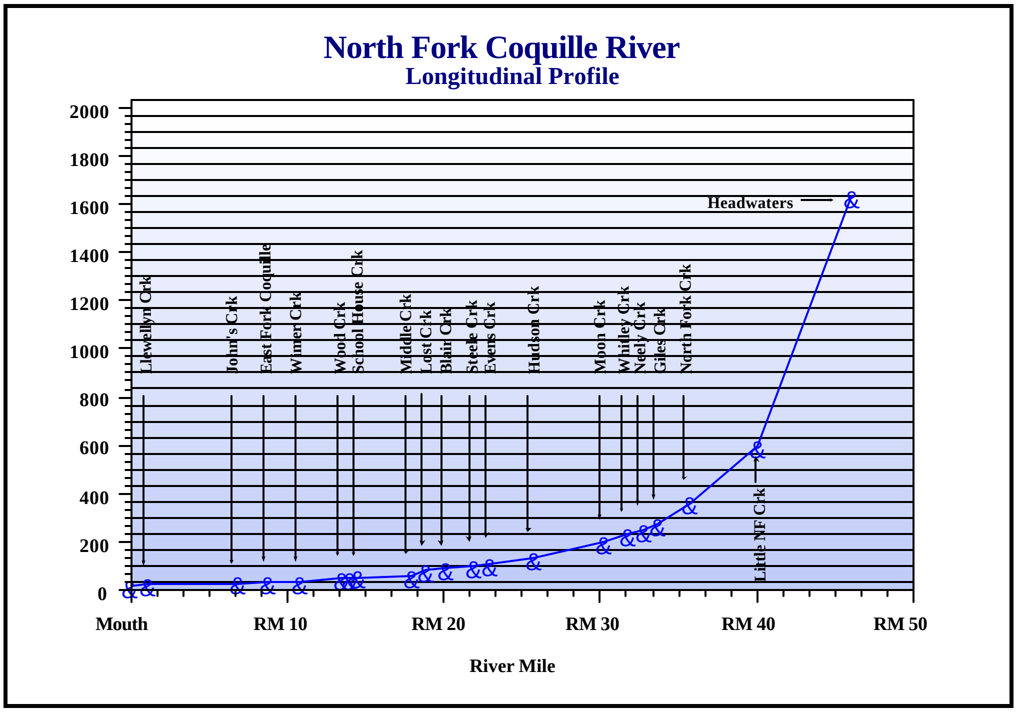
Subwatershed	Miles of Stream by Stream Order*							
	1	2	3	4	5	6	7	Total
North Fork Coquille	154	61	32	13	17	0	0	277
Middle Creek	202	70	31	14	23	7	0	347
Fairview	129	40	21	8	16	8	0	222
North Coquille Mouth	122	44	19	6	4	10	9	214
Total Miles	607	215	103	42	59	25	9	1060

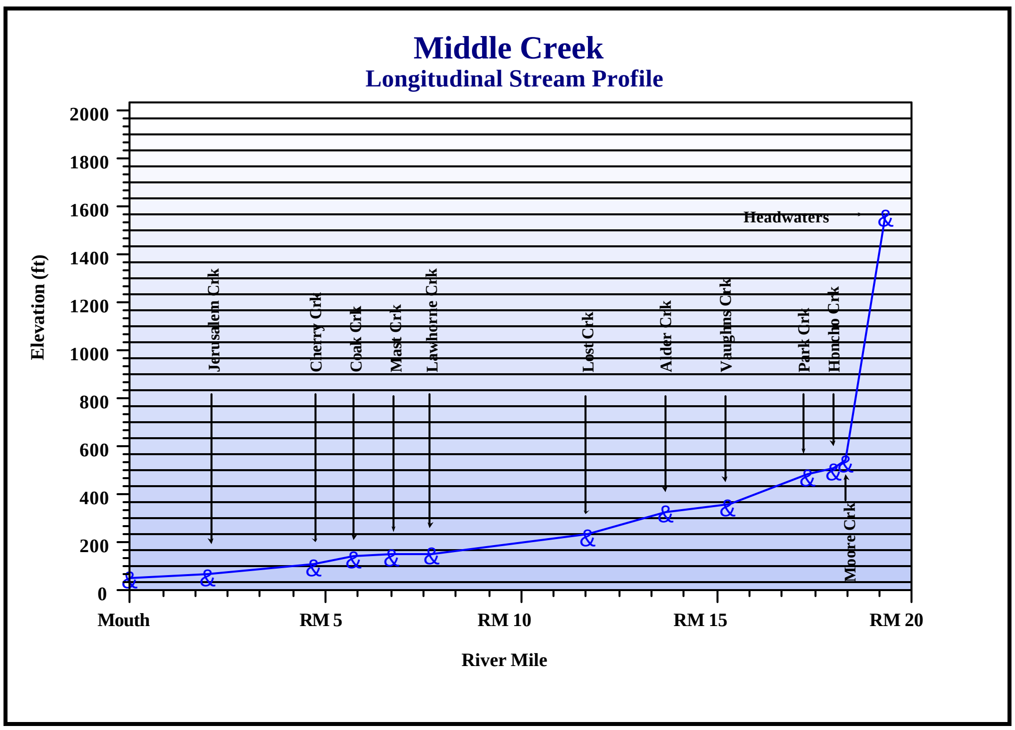
* Relative position of streams, where all exterior links are order 1, and preceding downstream, the confluence of two like orders result in existing stream order +1. The junction of two different orders retains the higher order, and the main stream always has the highest order (Strahler 1957).

Table Chan-2: Stream Order Density

Subwatershed	square miles	Drainage Density (mi/mi^2) by Stream Order*							all streams
		1	2	3	4	5	6	7	
North Fork Coquille	37.6	4.1	1.6	0.8	0.3	0.5	0.0	0.0	7.4
Middle Creek	50.7	4.0	1.4	0.6	0.3	0.5	0.1	0.0	6.9
Fairview	35.9	3.6	1.1	0.6	0.2	0.4	0.2	0.0	6.2
North Coquille Mouth	29.7	4.1	1.5	0.6	0.2	0.1	0.3	0.3	7.2
North Fork Coquille Watershed (all)	153.9	3.9	1.4	0.7	0.3	0.4	0.2	0.1	6.9

Longitudinal profiles: The longitudinal profiles of the stream gradient were developed for the mainstem North Fork Coquille and Middle Creek, by intersecting GIS contour and hydrography coverages and the results shown below. Stream gradient is a component of stream classification. The distribution of different aquatic organisms a long a stream is influenced by stream gradient.





Stream classification: Rosgen classification system provides a common language describing, classifying and comparing stream channel types (Rosgen 1994). Letter designation in the Rosgen's classification system identifies the channel gradient and other general hydraulic relationships. The number designation refers to the substrate type. The text "Applied River Morphology" (Rosgen 1996) explains this classification system in detail. Table Chan-3 below, displays the gradients and generalized hydraulic relationships for the 4 most common Rosgen Stream Types found in the North Fork Coquille Watershed. Many stream reaches will have different channel types at different locations along the reach, but due to the scale of this analysis, those local conditions would have to be addressed on a project basis. All of the drainages start as A type channels, evolve into B type, and finally into C and F type channels.

Table Chain-3: Rosgen Stream Types
(Channel material: 1 = bedrock; 2 = boulders; 3 = cobble; 4 = gravel; 5 = sand; 6 = silt/clay)

A Type Channels - headwater (A1a+, A2a+, A1, A2, & A6)	B Type Channels - step/pool (B1 - B4)	C Type Channels - pool/riffle (C4, & C5)	F Type Channels - pool/glide (F1-F6)
Low order headwater reaches characterized by high gradient (>4%), cascade, step-pool channel development. The channels with slopes <10% are designated as Aa+ types	Mid-order, moderate relief reaches characterized by 2-4% gradients.	Higher order, alluvial, broader valley reaches characterized by low gradient (<2%), meandering, point-bar, riffle/pool channel development.	Higher order, alluvial, broader valley reaches characterized by low gradient (<2%). Meandering. Central and traverse bar development.
Entrenched, with low width/depth ratios, low sinuosity(1.0 to 1.2), and have little flood plain development. The Aa+ channels are deeply intrenched.	Rapid-dominated, pool limited systems that are moderately entrenched, have a moderate width/depth ratio, moderate sinuosity, and limited flood plain development.	Not entrenched, have high width/depth ratios, high sinuosity, and have extensive flood plain development.	Deeply entrenched, sometimes structurally controlled, high to very high width/depth ratios at the bankfull stage, moderate to high sinuosity.
High energy (high sheer stress), dissipate energy through turbulent flow provided by the step/pool mechanism. This channel type is prone to debris torrents triggered by debris avalanches; can transport and deliver large volumes of sediment and woody debris.	Dissipate stream energy by maintaining stream velocities in the form of turbulent flow and overcoming resistance to flow provided by roughness.	Lower energy systems that dissipate stream energy through the channel geometry and the meander pattern.	Lower energy systems that dissipate stream energy through the channel geometry and the meander pattern. Can develop very high bank erosion rates, significant bar deposition and accelerated channel aggradation and/or degradation with very high sediment supply and storage capacities.
Stable when controlled by bedrock, boulders or large cobble.	Stable throughout the range of substrates.	Stable in bedrock/boulder controlled channels. Channels with other substrate size classes are unstable.	Stable in bedrock/boulder controlled channels. Channels with other substrate size classes are unstable.

In the North Fork Coquille Watershed, most A and Aa+ channel type streams are 1st and 2nd order streams. Most B type channels occur on 3rd and 4th order streams. The 5th order streams can have B, C and F type channels depending on stream gradient and intrenchment. The larger order streams typically have C and F type channels depending on the amount of entrenchment. These relationships between stream channel type and stream order are broad generalities. Many stream reaches will have different channel types at different locations along the reach.

<u>Very High Gradient Channels, Rosgen Aa+ Stream Types</u>: The Aa+ stream types are very high gradient (?10%), V-shaped, erosional, straight, channels. Aa+ stream types are found at the upper ends of drainages in dissected topography. These channels usually are 1st order streams.

A1a+ stream types are steep (>10%) stream types on bedrock and prone to the debris avalanche and shallow rapid debris flow process. The avalanches, debris slides and sometimes resulting torrents usually occur when concave hollows on headwalls above these channels are loaded with colluvium, soil materials and organic debris by natural or disturbance processes. Debris avalanches and shallow rapid debris torrents are primary in shaping and influencing these headwater V erosional stream channels.

Debris torrents are masses of water, mud. rock and large woody debris (LWD) that may move in excess 40 mph down the channel and scour the channel to bedrock. Depending on channel constrictions and amount of debris, torrents can also scour high bank areas. During debris torrents, materials sorting occurs where large rocks and LWD rise to the top. LWD in or suspended over the stream channel can slow and in some cases stop the advance of a debris torrent. Debris torrents occur as natural events in these stream types. These occurrences are linked to prolonged storms when daily precipitation exceeds 4 inches and soils are already saturated. The return period for this combination of conditions is not known for the Watershed but they appear to be associated with 5-10 year (or greater) recurrence interval storms. Road building and logging methods in common use before the mid to late 1970s accelerated the frequency of debris torrents in these channel types when compared to undisturbed forests. These stream segments transport rock weathering materials, sediment, LWD and nutrients through them chiefly by this episodic torrenting mechanism. These materials are deposited at channel constrictions or just above high angle (>70 degrees) tributary junctions (Benda 1985). These torrent deposits are reworked by the stream over a period of years and supply gravel and other particle sizes to downstream reaches. Debris torrents can temporarily dam higher order channels. Failure of these stream blockages can result in dam break floods. Normally this type of dam break flood occurs infrequently.

High Gradient Channels, Rosgen A Stream Types: The A streams types are high gradient (4.0-9.9%), V-shaped, erosional, straight channels which lack a flood plain. They are found at the upper end of drainages. Many are confined by bedrock channels and steep banks. They are usually 1st and 2nd order streams. The main process affecting these channels are infrequent landsliding and debris torrents. These channels are moderately sensitive to disturbance, have good recovery potentials and moderate stream bank erosion potentials. Sediment supply is low-moderate, except when fire or torrents occur.

Other Rosgen A Stream Types: The A6 channel types originate from seeps and have a very low continuous summer flow. They are typically first and second order channels occurring on silt/clay substrates. Some of these channels drain perched water layers in deep soils on gently sloping land forms. They are very sensitive to disturbance, have poor recovery potentials and very high streambank erosion potentials. Sediment supply is very high.

Moderate Gradient Channels, Rosgen B Stream Types: The B stream types are moderate gradient (2-3.9%), slightly meandering, step/pool streams with limited or no flood plain. Boulders and cobbles dominate the substrates and these streams receive frequent inputs of sediment. The B stream types have little transport capability beyond catastrophic landslide or flooding events. These third through fifth order streams receive water, gravels and sediment, nutrients and some LWD inputs from the headwater stream types. The B type channels have larger drainage areas, greater flows than the A types, and most are 3rd or 4th order perennial streams. Few B type channel streams in the analysis area are unaffected by past management and most of those are in the LSR part of the Watershed.

The time from the onset of precipitation to the point of peak run-off is rapid for tributary step/pool streams. This is because the distances and travel times from the first through third order headwater streams are uniform due to the dendritic stream pattern. The rapid rise and fall pattern does not allow for lengthy transport of LWD. In contrast, the peak flow for the mainstem step/pool stream types is delayed and the duration may be extended depending on how synchronized the run-off is from the tributary streams. Management activities can influence the extent of run-off synchronization in the tributary streams. These streams are the transitional streams between the headwater streams and the pool/riffle dominated streams.

Historically in the Watershed, this channel type contained steps formed by large wood embedded in the channel that dissipated stream energy and prevented lateral adjustment or bankcutting. Embedded LWD spanning the channel created low velocity flats onto which sediments were deposited for long term storage. The main processes affecting these channels are the input of water, sediment and LWD from upslope channel segments, and some naturally occurring bankcutting and entrenchment in response to changes in LWD levels and positions in the channels. Salvage logging and stream cleaning in this channel type reduced the naturally occurring levels of LWD in the affected channels resulting in channel widening and downcutting or entrenchment. Normally, sediment accessed from streambanks, or moved in from upstream stream types (A types), are temporarily stored behind obstructions or localized flats where natural stream grade controls are present. Where stream slopes exceeds about 2%, fine and coarse sediments are moved downstream during frequent flows. This stream type will not aggrade, even when sediment supply is high. However, without LWD wood structure in the stream, limited areas are available to trap gravels for fish spawning beds.

Under undisturbed conditions these stream types are moderately entrenched, riffle dominated types, with stepping features of infrequently spaced large pools at bends or areas of constrictions, and interspersed with cascades.

Low Gradient Channels, Rosgen C and F Stream Types: C stream types are low gradient (< 2%), meandering, wide, slightly entrenched to entrenched, pool/riffle streams with adjacent flood plains with a variety of substrates but with a high proportion of fines. They have large watershed source areas and are usually 4th order or greater streams located lower in the drainages. Most C channels are perennial streams, which flow through narrow flood plains, that develop upstream of channel restrictions (e.g., narrow valley widths, partial debris dams, etc.) or in alluvial valleys. These channels dissipate energy by meandering and flowing over rough material along the bank and streambed. The probable historic condition for these channel types included narrow streams which overflowed the stream bank and used the flood plains during floods. Their stream banks were stabilized by root masses including myrtle, maple, cedar and other tree species. Greater amounts of LWD were in these channel types, but living trees provided bank stability and were more important than the influence of log steps. These channels dissipate energy by meandering and flowing over roughness elements along the banks and streambed.

F stream types are similar to C types, but are vertically lowered and have no flood plain. This channel type can occur naturally. Management activities that reduce channel roughness or restrict meandering of C type channels can result in down cutting, changing the channel into a F type.

Current Conditions
The following are some of the channel and flood plain changes observed in the Watershed that resulted from past human activities:

Large areas of flood plain have been cleared and drained for development. The loss of vegetation maintained stream bank stability resulted in increased stream bank erosion. The loss of wood recruitment to the channel, along with loss of stream bank vegetation, reduced channel roughness. This in turn resulted in higher stream velocities that contribute to increased stream bank erosion and down cutting, and the loss and/or simplification of habitat, especially aquatic habitat that is critical during high flows. Down cutting resulted in some C type channels changing into F channel type.

Removal of stream side and flood plain vegetation has decreased the flood plain roughness. Flood plain roughness normally slows the movement of flood waters and the slower the water moves the more sediment settles out on to the flood plain. With less flood plain roughness, more sediment remains suspended in the flood waters to be deposited farther down stream and in the estuary.

Much of the channel roughness provided by LWD has been removed, which changed the flow from a turbulent or varied-velocity profile, to a laminar or consistent-velocity profile. As a result, the amount of backwater or low velocity, depositional areas provided by turbulent flow have been reduced. A decrease in the number velocity breaks has caused the channels to down-cut.

Many larger channels have scoured to bedrock or migrated laterally and have difficulty retaining substrate. Other channels that can otherwise retain a substrate may have difficulty recruiting it due to the present road system. The stream-side and mid-slope roads function as terraces that stop landslides that would have normally delivered material to the channel.

Improperly sized culverts limit substrate recruitment by not transporting bedload down through the channel network. Undersized or blocked culverts can impound water and cause road failures that lead to large inputs of sediment.

The A and B type streams are confined by narrow valley morphology and bedrock, and therefore resist changes in slope, entrenchment, and sinuosity. Based on these characteristics, the A and B type channels in the managed landscape have changed little from their premanagement condition. Under premanagement conditions, the A and B type channels were dynamic systems where disturbance processes both delivered wood to these channels, and removed wood from these channels to be deposited in down stream in lower gradient reaches. In the managed landscape, large wood was lost from A and B channels where instream wood was removed by logging, overly aggressive stream cleaning, and as a result of debris torrents precipitated by road failures. Removal of large conifers that could reach the streams has diminished the contribution of large woody material into the streams. The loss of wood has not caused the A and B type streams to change into a different channel type, but has reduced instream habitat diversity, and changed the way the A and B type channels influence down stream reaches. The A type channels store sediment and wood and are sources of these materials for permanently flowing streams (FEMAT 1993, p V-36). Large wood captures and stores sediment and is critical in maintaining step-pool morphology in the A and B type small headwater streams. Research showed as much as 15 times the annual sediment yield stored behind wood in Idaho streams and between 100 to 150 years of average annual bedload stored behind wood debris in steep tributary streams in northern California (Megahan 1982; Keller *et al.* 1995, both cited in Curran 1999). The step-pool morphology has the potential to delay flow from these tributaries during storm events and reduce peak flows downstream. A recent study by Curran (1999) found the spill resistance in step-pool reaches contributed 90% of the friction that slows water velocity in some western Washington headwater streams.

The current condition of channels in this watershed is best understood by discussions on the interaction of human caused disturbance, natural disturbances and the tendency for streams to self regulate toward a stable condition following disturbance. These interactions are covered in the synthesis and interpretation subsection. The Erosion Processes chapter includes a history of management activities that affected sediment and large wood delivery to the streams. The Human Use section includes a history of managing the major channels for navigation and water transport of logs.

Reference Conditions

Few low gradient reference condition stream reaches exist within the watershed and none are larger than 5th order and all flow through the Tyee Formation. These reaches are:

5th order	North Fork Coquille River	sections 16, & 21 T.26S.,R.10W.
4th order	North Fork Coquille River	sections 15, & 22 T.26S.,R.10W.
4th order	Alder Creek	sections 30 & 31, T.26S.,R.10W.
4th order	North Fork Cherry Creek	section 18, T.27S.,R.10W.
3rd order	Little North Fork Coquille	section 19, T.26S.,R.10W.

While these are useful reference reaches, they are not pristine in that some of their headwater streams have been affected by past logging and road building. Also roads, salvage logging, and stream cleaning have altered some stretches within the reference reaches on Alder Creek and the North Fork Coquille River. The 1st and 2nd order streams that flow through areas unaltered by the direct affects of management are more common. Here too, nearly all 1st and 2nd order drainages, which are unaffected by forest management activities and road construction, are on the Tyee formation. Examples of these are in the same sections that contain the reference low gradient reaches listed above. Additional unlogged and unroaded 1st and 2nd order drainages are present in other locations on BLM land in the Watershed.

Beaver dams and high densities of LWD in log jams in the unmanaged landscape had a role in maintaining pools and storing water in the channel and as ground water in the streambanks. This water was slowly released during the summer augmenting low flow water levels.

The Erosion Processes Characterization and Reference Condition sections, in this document, address the sediment sources and delivery mechanisms in the Watershed before Euro-American settlement.

Synthesis & Interpretation

The different channel types have different dimensions, patterns, and profiles, and will respond differently to disturbance as well as restoration efforts. Table Chan-3, below, lists some structures that may be appropriate for instream work by channel type, however, proposed projects have to be evaluated on-site to determine suitability.

Table Chan-3: Appropriate In-stream Structures by Channel Type (Rosgen 1996)

Type A Channel	Type B Channel	Type C Channel	Type F Channel
Channel edge boulders	Very few limitations	Channel edge boulders	Channel edge boulders
Vortex rock weirs		Channel edge root wads	Channel edge root wads
Channel edge root wads		"W" Weir or vortex rock weir	"W" Weirs or vortex rock weirs
		Bank cover	Bank cover

notes:
Channel edge boulders are not the same as riprap. Channel edge boulders are placed in the stream to provide instream cover and scour pools. Strategically placed boulders can divert high stream flows away from unstable banks. In contrast, riprap is a blanket of rocks intended armor stream banks and by that prevent channel movement.

Descriptions, illustrations and discussions on appropriate instream structures for each channel type are covered in the Applications section of the book <u>Applied River Morphology</u> by Rosgen (1996).

<u>Management Affects on Stream Channels</u>: Log transport early in the management history of the Watershed, construction of roads that restrict both channel migration and stream access to flood plains, loss of streamside vegetation, and loss large wood from instream and streamside locations directly affected sediment and large wood debris storage and recruitment, and altered stream channel functions and stability. Logging and stream cleaning associated LWD loss from the stream channels have caused degradation in all stream types, especially the moderate gradient B stream types. Channel complexity provided channel roughness that dissipated stream energy through turbulent flow and channel roughness. Removing the LWD from streams reduced channel roughness causing stream flow to change from turbulent (varied velocity profile) to laminar (consistent velocity profile). As a result, the amount of backwater or low velocity, deposition areas provided by turbulent flow have been reduced considerably. The decreased number of velocity breaks caused the channels to down cut and widen to dissipate stream energy no longer used in the step/pool flow pattern.

Before stream buffers became a common practice, the stream side trees that anchored stream banks were cut during logging operations. The loss of the streamside vegetation destabilized stream banks causing channel instability along the low gradient C stream types. This combined with the removal of large wood from these channels for navigational, economic, and fish passage purposes resulted in the flood plain streams down cutting and widening. This lowered the water table in the flood plain, and by that reduced the ability of ground water to augment stream low flows. The down cutting also converted many C stream types to the entrenched F type.

<u>Sediment Transport and Depositional Processes</u>: The A and B stream types, because of their steep gradients, rapidly transport coarse and fine sediment through them. These streams transport most sediment during only a few storms each winter. The limited sediment transport capacity outside of storm events is the result of low flow volumes attributable to the small catchment areas above the A and B type channels. Debris avalanches and debris torrents are the most important transport mechanisms of coarse and fine sediments in the Watershed. Areas that show the most evidence of debris avalanches and torrents from natural conditions and road and channel intersection failures are found in the upper watershed in the Tyee formation. Mid-slope roads acting as interceptors, channel landform constrictions, LWD, and debris torrent deposits can slow the routing process (additional discussion in the Erosion Processes Chapter). Once depressions are filled by sediments behind obstructions, a new equilibrium is reached and incoming sediments will be held in suspension during the frequent flows and moved downstream. Sediment stored behind LWD or in debris fans will remain in storage for long periods. It can be mobilized again when the organic debris decay or a flood flow rearranges channel debris.

The C channels are low gradient, and the active channel dimensions are maintained by the frequent flows. These channels are unconfined at flood stage and entrained sediment will deposit on adjacent lateral flood plains. This is because the flood plains have wide areas spreading water at shallow depths and vegetation providing roughness, which lowers velocity to where coarse and fine sediments cannot be held in the water column. The C channels tend to be stable. If chronic or frequent pulses of sediment from upstream activities overwhelm the transport capability of the stream, aggradation will occur at moderate flows. With a high sediment supply, high flows will build a new higher flood plain, but the C channel will retain its approximate channel dimensions, but at a higher base level in the valley. Although the sediment supply is high, the surface streambed armor layer does not appear to be overwhelmed with fine sediments. Most coarse and fine sediments are near the bankfull stage at the margins of the active channel. This implies sediment transport is flow limited rather than supply limited.

Some F channels in the analysis area have converted from C types, including much of the lower reaches of the North Fork Coquille and Middle Creek. These are low gradient, entrenched, moderate width channels. Cycles of scour and fill and movement downstream with coarse and fine sediments at moderate flows will continue in these channels until they widen sufficiently so that the cross sectional area diminishes water velocity, depositing sediments during frequent or high flows. In this way a new floodplain will be built by the river within the entrenched channel.

<u>The Affects of Channel Morphology and Riparian Vegetation on Low Flows</u>: Water availability during late summer from base flow inherently is poor. This is due to the comparatively thin coarse-textured soils, which covers most of the Watershed, providing little ground water storage. There is an implied assumption that the low flow hydrology of the drainages has changed in response to natural events and management activities. This assumption is based on studies in similar drainages. A good discussion on the changes of low flow can be found in Part II, Chapters 3 of "Monitoring Guidelines to Evaluate Effects of Forestry Activities on Streams in the Pacific Northwest and Alaska" (MacDonald *et al.* 1991). Changes in channel morphology and riparian vegetation have affected low flows. Removal of forest vegetation has been shown to increase low flows by reducing evapotranspiration (Harr *et al.* 1979). However, because summer streamflows are very low in the South Fork Coos Watershed, the additional volume of water yielded from harvested areas is small. Conversion of tree species from conifer to red

alder, can decrease summer low flows from preharvest conditions, because alders transpire more water than conifers during the summer (Hicks *et al.* 1991).

Morphological changes affecting the retention of low flows in the high gradient (>10%) low order (1-2) high energy channels have been slight. These correspond to the A type channels. Because most of these channels are intermittent; they do not retain summer water. Exceptions are channel types A5-A6 draining deep soils or small perched water tables. Some type A channels have been scoured to bedrock by debris flows. In regeneration harvest units, LWD has been removed from these channels, which acted as energy dissipation steps and sediment catchments. However, this change is not thought to affect retention of summer water.

Morphological changes affecting the retention of low flows in the moderate gradient (2-10%) middle order (2-3) transitional channels have been moderate. These are step/pool A and B type streams. Removal of LWD has simplified these streams by eliminating the steps created by the wood and the flats that had formed behind them. These flats stored large volumes of sediment and near surface groundwater. The depths of the pools, below each step, and the pool frequencies are greater those reaches with instream LWD than in those reaches that have lost their LWD. During the summer low flow period, the greater near surface groundwater storage, and the larger more frequent pools allow more summer storage of water in those channels with LWD.

Morphological changes affecting the retention of low flows in the higher order (4-8), low gradient (<2%), depositional stream channels, have been the greatest. On some reaches of the North Fork Coquille and Middle Creek, the down cuts were deep enough to convert those reaches from C type to F type channels. The more deeply a stream cuts down, the lower the watertable becomes in the adjacent flood plains and terraces. As the water table lowers, the amount of ground water available to feed into the streams during the summer drought period becomes less. This results in lower flows during the summer drought period that often limit fish habitat and cause water shortages for domestic and agricultural use. Also, high flows in channelized streams that were historically unconfined contribute to accelerated channel scouring, sedimentation, and bank failure as these stream types try to reestablish a more stable dimension, pattern and profile.

<u>Changes Affecting Channel Width of Depositional Streams</u>: Many C type channels have become wider with a corresponding reduction in stream depth. The widening is, in part, in response to the loss of channel and flood plain roughness. Channel roughness slows the stream velocity, and by that reduces a stream’s capacity to transport sediment and cause stream bank erosion. Before snagging and stream cleaning operations, and the reduction in the sources of large wood, channel roughness was provided by large wood in the channel, on the stream banks, and during floods by wood on the flood plains. Channel and flood plain roughness was also lost when structurally complex vegetation was replaced with structurally simpler plant communities that provide less flow friction during high flows and floods.

Wide, shallow streams retain little water in pools. Sediment delivery from upstream sources may have further decreased pool volume by filling. Wide shallow streams are at greater risk of higher water temperatures in the summer than streams that are narrow and deep. This is due to wide shallow rivers having a greater surface area, for a given volume, that is exposed to solar heating. Down cutting in this channel type has reduced the streams access to the flood plain reducing the influence of flood plain roughness on stream velocity following major storms and on sediment retention.

<u>Stream Channel Trends</u>: The A1 channel types are confined by topography and bedrock, and therefore resist change to channel form. A5-A6 stream types are degrading at a slow rate due to headcutting. B stream types are continuing to degrade, where they lack sufficient LWD to form log steps, and when the

base level is above bedrock. Some C stream types within the Watershed have converted to an F type, and cannot reasonably return to a former state. This channel entrenchment has drained much of the flood plain's stored water. Many F stream types would require sharp rises in the base level to reconnect with their flood plains, and that may not be possible under the present climate. It is more likely that eventually the F channel types will widen by bank cutting processes, and the river will construct a flood plain within the overfit channel. Bank cutting is being slowed in some reaches by bank materials and properties. Eventually, a C channel type may be restored within some wide F segments, but may take many years.

On those streams where a level of channel restoration was obtainable, instream structures like log and boulder weirs, have reversed the degradation by retaining sediments suitable for spawning and invertebrate habitat and increasing summer time in channel water storage. However, these reaches still lack the high level of structural complexity associated with intact systems that are operating at their full potential. In-stream structures have been installed on most of the accessible sites on BLM land where such structures would be beneficial. The remaining suitable sites are generally less accessible and in some cases require a higher level of design to be successful. At this stage the greater opportunity to do instream restoration is on private land.

<u>Stream side vegetation and channel type</u>: As stream size increase, hardwoods (red alder, bigleaf maple, myrtle and Oregon ash) become a more important component of the riparian forest. Hardwoods can dominate the lower elevation narrow flood plains, areas subject to seasonally saturated soils, and areas subject to frequent disturbance. Conifers maintained a presence on the larger flood plains prior to land clearing for agriculture and the early timber harvests however these areas were dominated by hardwood species (Dodge 1898, pp. 169; Howard & Huffer 1875). Rot *et al.* (2000) observed the species composition on flood plains was distinctly different from other streamside landforms. The flood plain plant community composition was controlled by relatively high flood frequencies and numerically dominated by hardwoods, however, conifers represented a higher basal area. Conifers on flood plains were restricted to microtopographic ridges, tops of logs, and protected areas such as behind LWD accumulations. LWD accumulations sometimes may also protect conifer seedlings form browse damage. Rot and coauthors (2000) suggest that LWD on the flood plain provides an indirect service to the stream channel by providing protected microsites needed for conifers to survive and grow in close proximity to the stream.

<u>Management Recommendations:</u>
The following are several strategies which should be considered to restore degraded channel conditions, water quality, and riparian and floodplain habitat and function.

- Enhance the growth and structural integrity of historic riparian vegetation through the use of tree planting, thinning, and species conversion.
- Design and place log and rock in-stream structures on public and private lands, in conjunction with Watershed Associations, to restore and enhance habitats and the stable dimension, pattern and profile of stream types.
- Look for opportunities to restore incised stream channels by designing and/or creating new stream channels or by using old oxbows on top of abandoned flood plains.
- Remove, resize or retrofit improperly sized culverts to reduce flow velocities, allow free passage of sediments and debris and allow for passage of vertebrate and invertebrate aquatic species.
- Look for opportunities to decommission, reroute or improve drainage on existing or abandoned roads. Highest priority should be given to streamside and midslope roads.

References

Benda, L.E. 1985. *Delineation of Channels Susceptible to Debris Flows and Debris Floods*. In: International Symposium on Erosion, Debris Flow, and Disaster Prevention. Tsukuba, Japan. 195-201.

Curran, J.H. 1999. *Hydraulics of Large Woody Debris in Step-Pool Streams, Cascade Range, Washington*. Masters Thesis. Colorado State University

Dodge, O. O. 1898. *Pioneer History of Coos and Curry Counties, Or. 2nd ed*. 1969. Bandon, Or. 468 pages.

FEMAT (Forest Ecosystem Management Assessment Team). 1993. *Forest Ecosystem Management: an Ecological, Economic, and Social Assessment*. USDA and USDI. Portland, OR.

Harr, R.D., R.L. Fredriksen and J. Rothacher. 1979. *Changes in streamflow following timber harvest in southwestern Orego*n. USDA Forest Service. Res. Pap. PNW-249. 22 p.

Hicks, B.J.; Beschta, R.L.; Harr, R.D. 1991. *Long-term Changes in Streamflow Following Logging in Western Oregon and Associated Fisheries Implications.* Water Resources Bull. 27(2):271-226.

Howard, J.; Huffer, J.H. 1875. *Field Notes of the Survey of the Subdivision of Township 28 South, Range 12 West of the Will. Mer*. Contracted by the General Land Office (now the Bureau of Land Management).

Keller, E.A.; MacDonald, A.; Tally, T.; Merrit, N.J. 1995. *Effects of Large Organic Debris on Channel Morphology and Sediment Storage in Selected Tributaries of Redwood Creek, Northwestern California*. In: Nolan, K.M.; Kelsey, H.M.; Marron, D.C. (editors). Geomorphic processes and aquatic habitat in Redwood Creek Basin, Northwestern California. USGS Professional Paper 1454-P. pgs 1-29.

MacDonald, L.H., A.W. Smart and R.C. Wissmar. 1991. *Monitoring guidelines to evaluate effects of forestry activities on streams in the Pacific Northwest and Alaska*. Seattle, WA: U.S. Environmental Protection Agency, Region 10. EPA 910/9-91-001.

Megahan, W.F. 1982. *Channel Sediment Storage Behind Obstructions in Forested Drainage Basins Draining the Granitic Bedrock of the Idaho Batholith*. In: Swanson, F.J.; Janda, R.J.; Dunne, T.; Swanston, D.N. (Editors), Gen. Tech. Rep. PNW-141. USDA, FS, Portland, OR. pgs 114-121.

Rosgen D.L., 1994. *A classification of natural rivers*. Catena. 22:169-199

Rosgen, D.L. 1996. *Applied River Morphology* Wildland Hydrology, Pagosa Springs, CO.

Rot, B.W.; Naiman, R.J.; Bilby, R.E. 2000. *Stream Channel Configuration, Landform, and Riparian Forest Structure in the Cascade Mountains, Washington*. Can. J. Fish. Aquat. Sci. 57:699-707.

Strahler, A.N. 1957. *Quantitative analysis of watershed geomorphology*. Trans. Amer. Geophys. Union. 38:913-920.